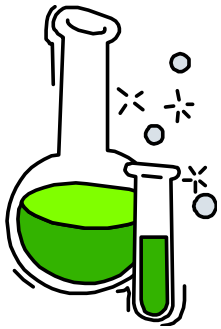
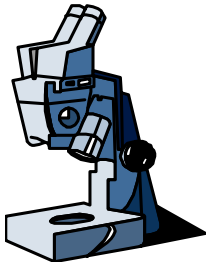
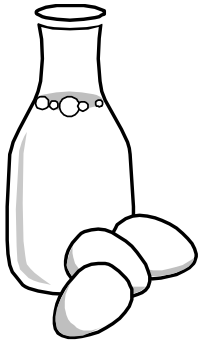
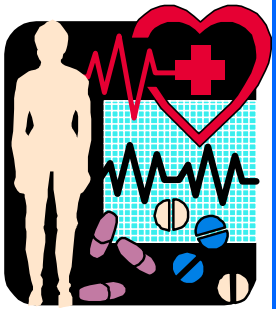
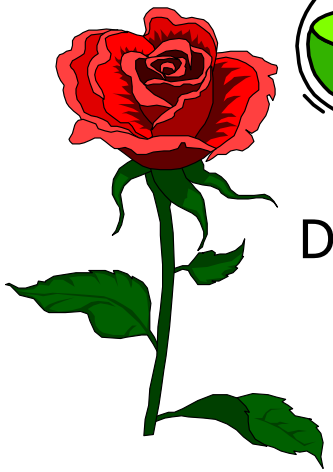
Cold Chain-Management II
Time-temperature Integrators and the Cold chain: What is next?
Bonn Germany 5/8/06


Dr Ted Labuza & T. Myers
Department of Food Science and Nutrition, U. Minnesota
Infratab Raytheon Way Oxnard CA
tplabuza@umn.edu & tmyers@infratab.com

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ERS estimates only losses by retailers, consumers, and foodservice[1]...

Retail

- 5.4 billion pounds of food were lost at the retail level in 1995.
- Retail losses were less than 2 percent of edible food supplies.
- Dairy products and fresh fruits and vegetables accounted for half of retail losses.

Consumer and foodservice

- 91 billion pounds of food were lost by consumers and foodservice in 1995.
- Foodservice and consumer losses accounted for 26 percent of edible food supplies.
- Fresh fruits and vegetables accounted for nearly 20 percent of consumer and foodservice losses.

Note: [1]Foodservice and consumer losses include storage, preparation, and plate waste at the household and foodservice levels. Source: Economic Research Service, U.S. Department of Agriculture.

U.S. Regulatory Stance on Shelf Life

- Federal Laws
  - Required for drugs, OTC and infant formula
    - Drugs 10% loss below label value on lower 95% CL line
  - All other food products voluntary - no mention in regs
- State laws
  - 30 states regulate some dates (dairy, meat)
  - Minnesota ≤ 90 days
  - None based on safety more for commerce

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EU Dating Rules

Directive 97/4/EEC Article 9 of 79/112/EEC.

1. ***The date of minimum durability of a foodstuff shall be the date until which the foodstuff retains its specific properties when properly stored. It shall be indicated in accordance with the provisions of this article.***

2. ***The date shall be preceded by the words:***
--"Best before…" when the date includes an indication of the day,
--"Best before end…" in other cases

3, ***In the case of foodstuffs which, from the microbiological point of view, are highly perishable and are therefore likely after a short period to constitute an immediate danger to human health, the date of minimum durability shall be replaced by the "use by" date.***

☐USDA -FSIS 1998

Guidance for Beef Grinders to Better Protect Public Health

Guidance for Minimizing Impact Associated with a Food Safety Hazard in Raw Ground Meat and Other FSIS Regulated Products

Install a time-temperature indicator on the package to indicate adequate temperature of storage, distribution, and display (in grocery and other retail establishments).

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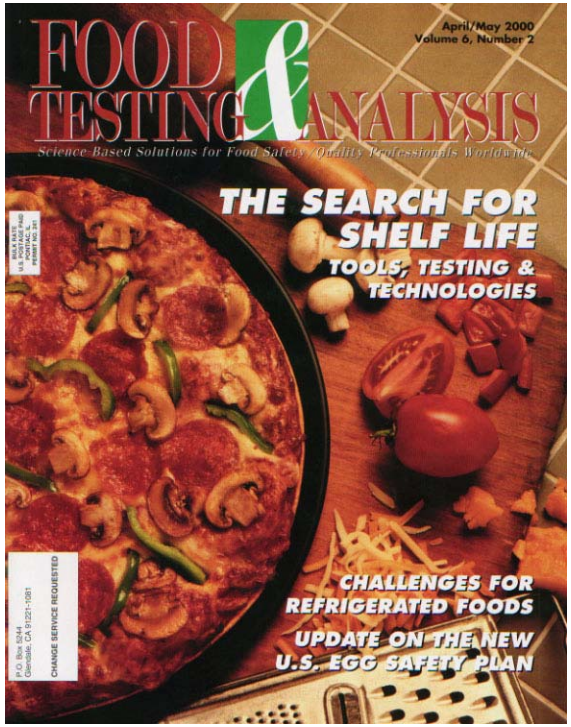
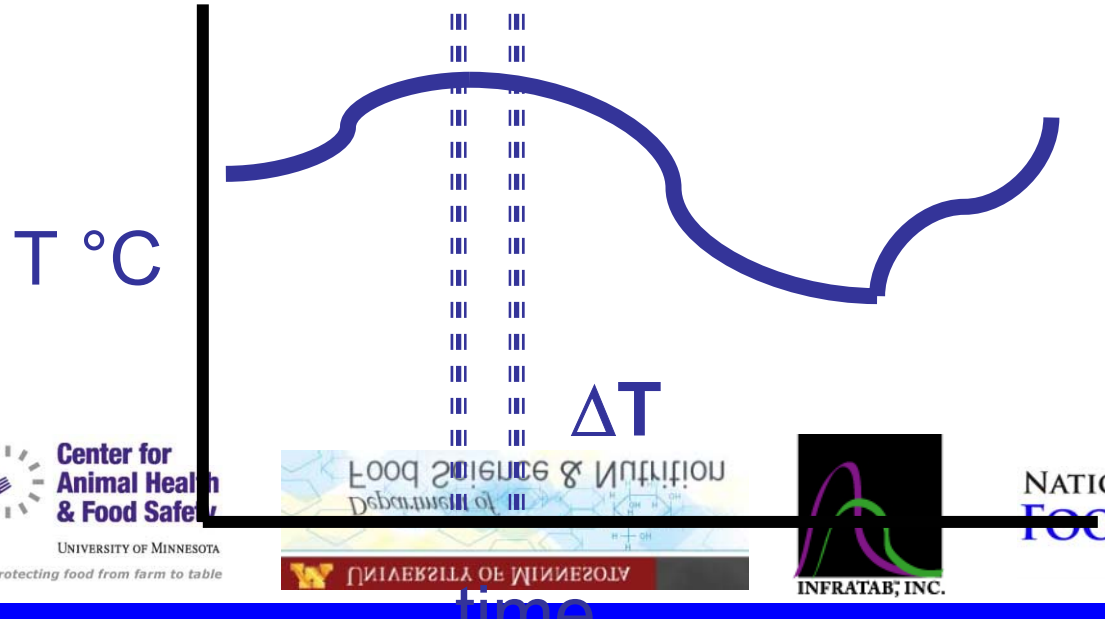
Time Temperature Integration

- Combine T vs t, k and E_a functions in algorithm
  - Temperature vs time measurement
  - Algorithm for Reaction extent as f(t,T)
  - Shelf life plot needed





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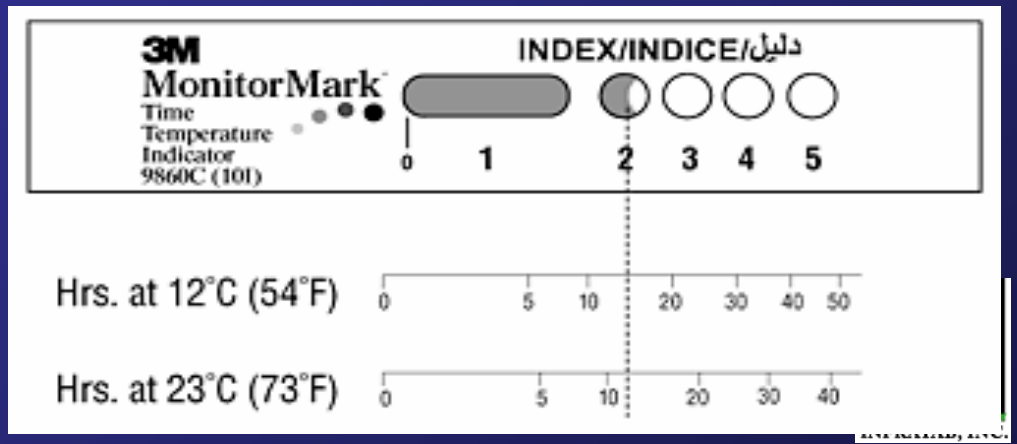
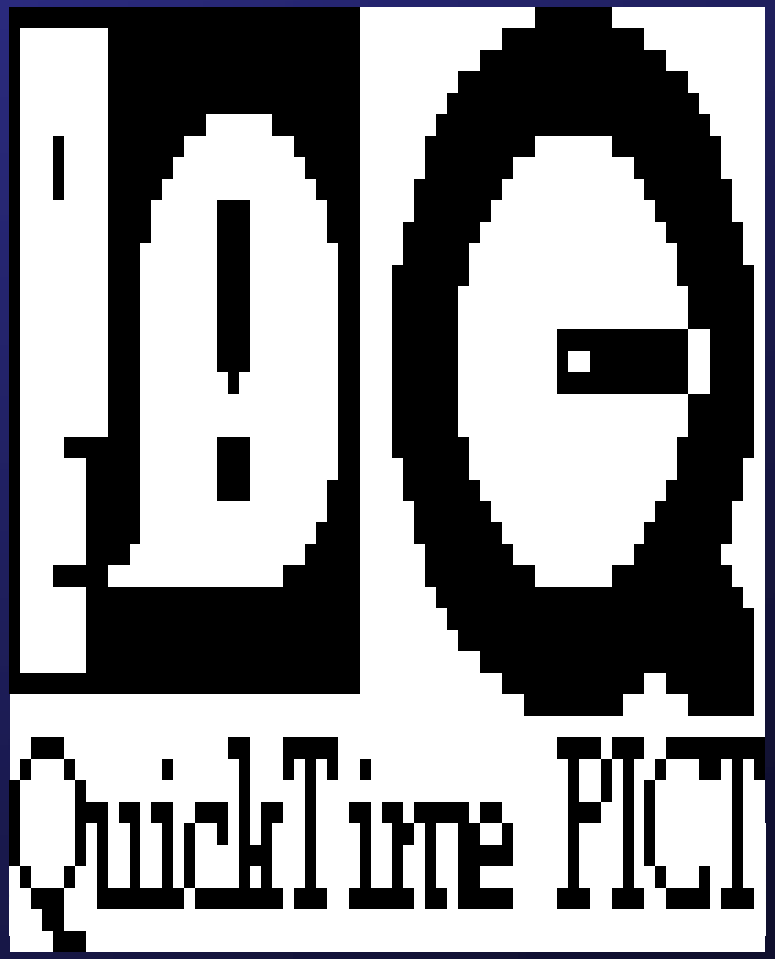
http://www.fdcpackaging.com/temperature/time_indicators.html

3M Diffusion Tag for WHO MMR program





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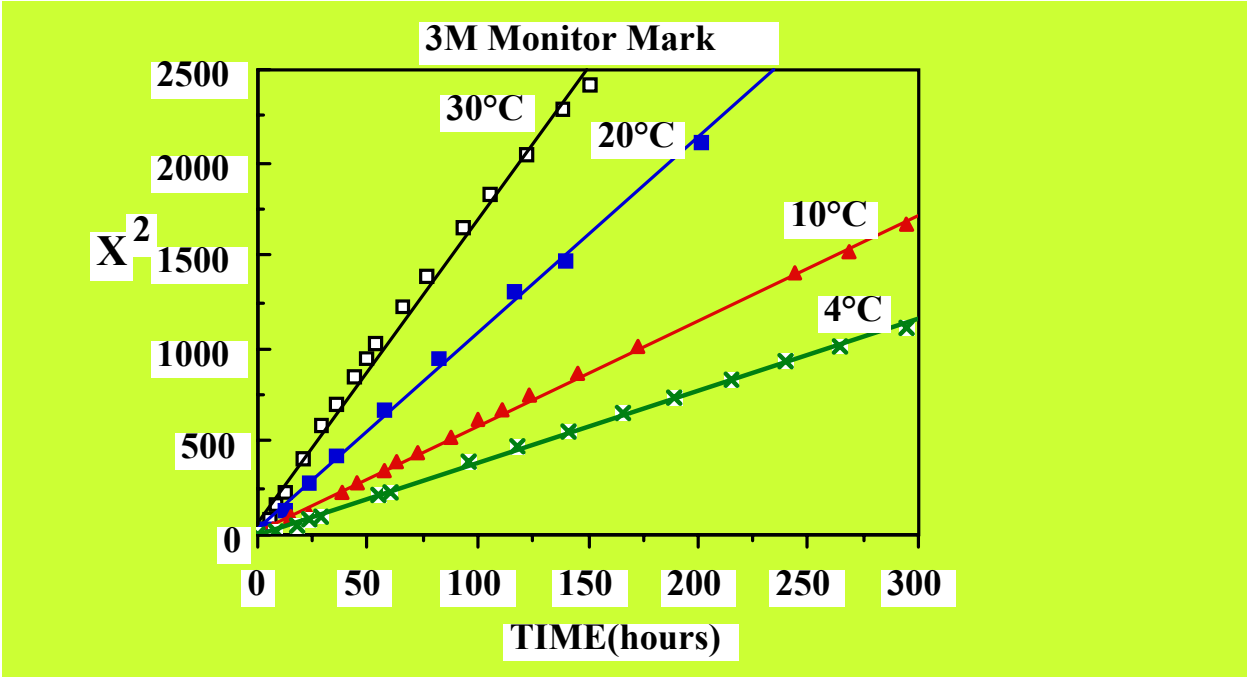
Diffusion Kinetics for 3M tag



Crank derivation $x^2 = k\,t$

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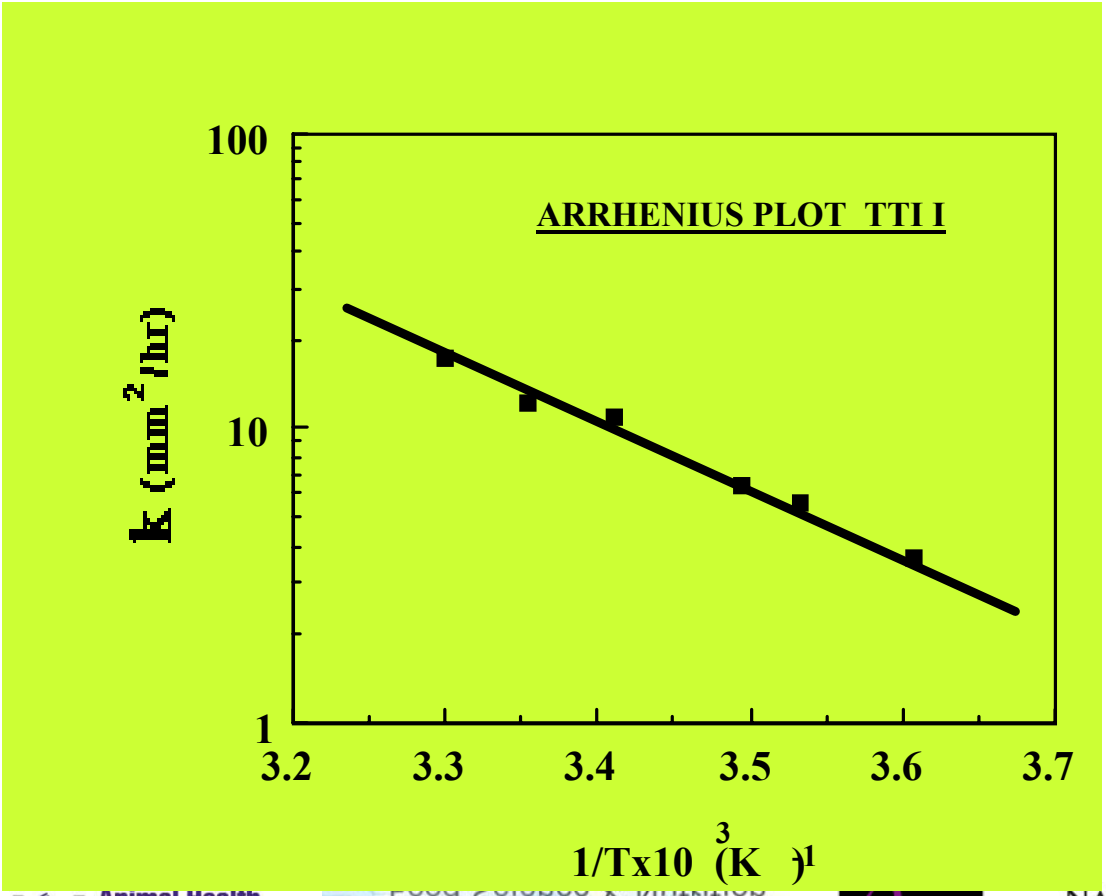
3M MonitorMark

$$\ln k = k_o e^{-E_a/RT}$$



E_a ~ 5 to 9 Kcal/mole vs food at 12 to 40 Kcal/mole

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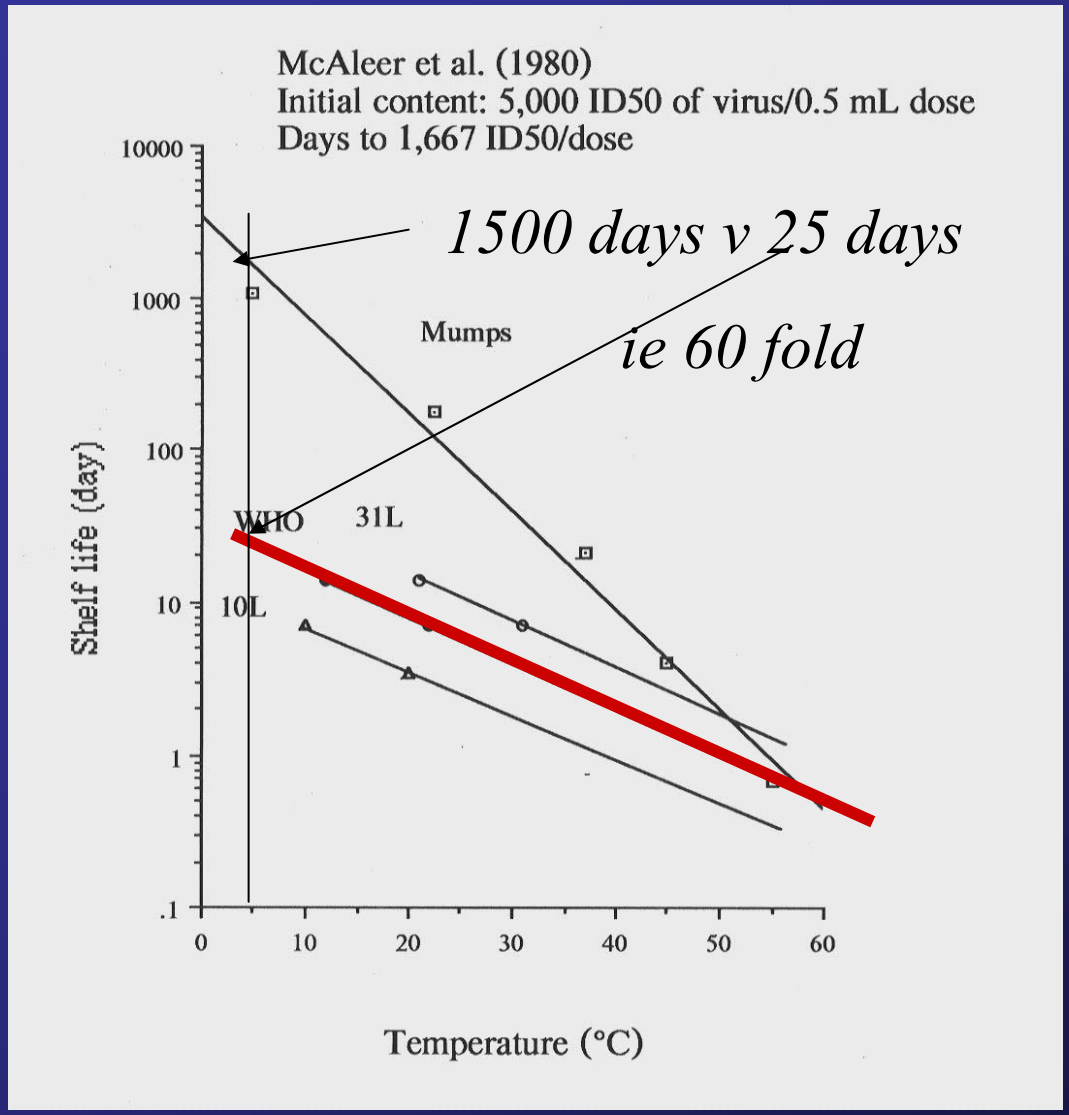

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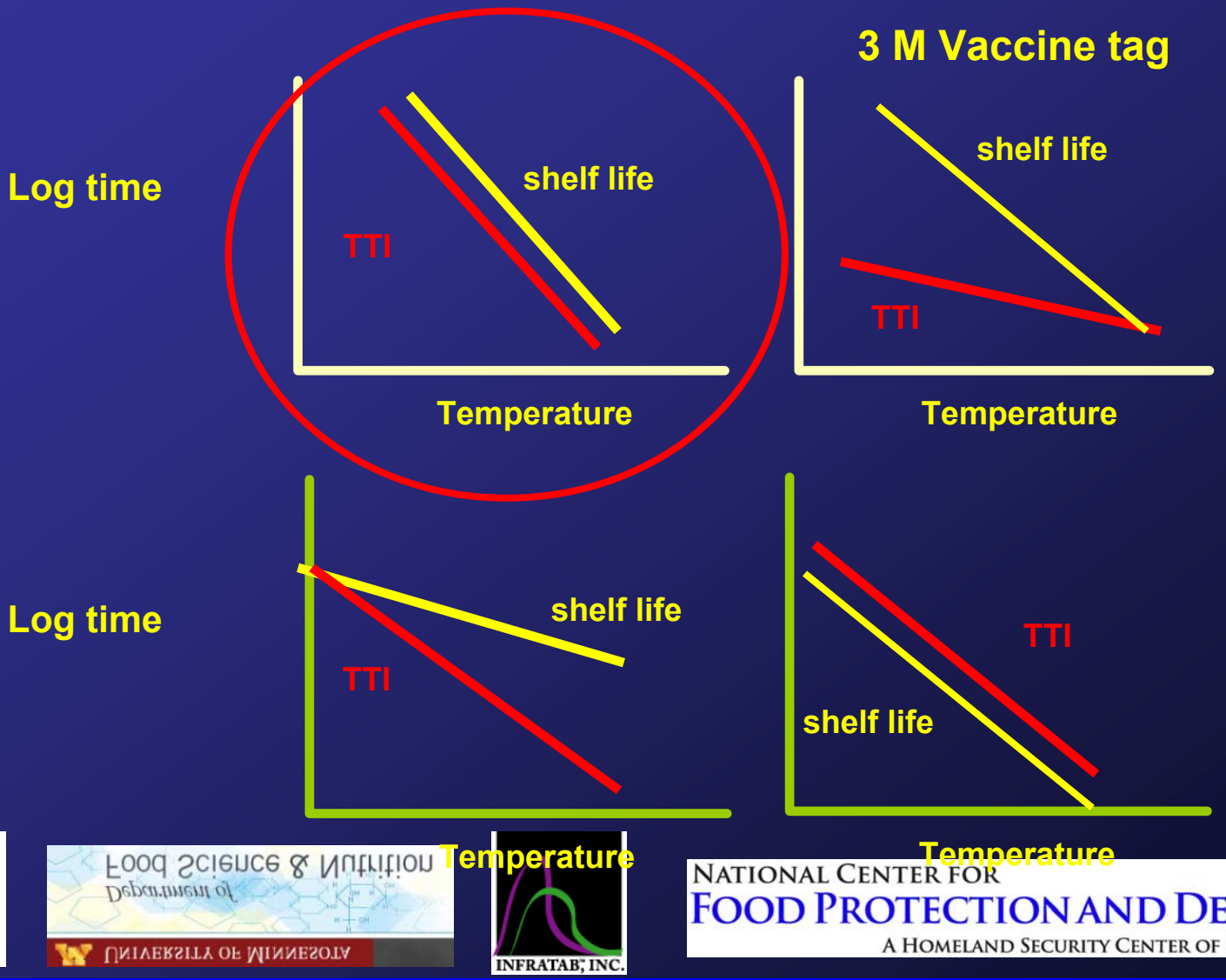
Shelf Life plots food or drug vs tag

Illustration of proper and improper TTI design



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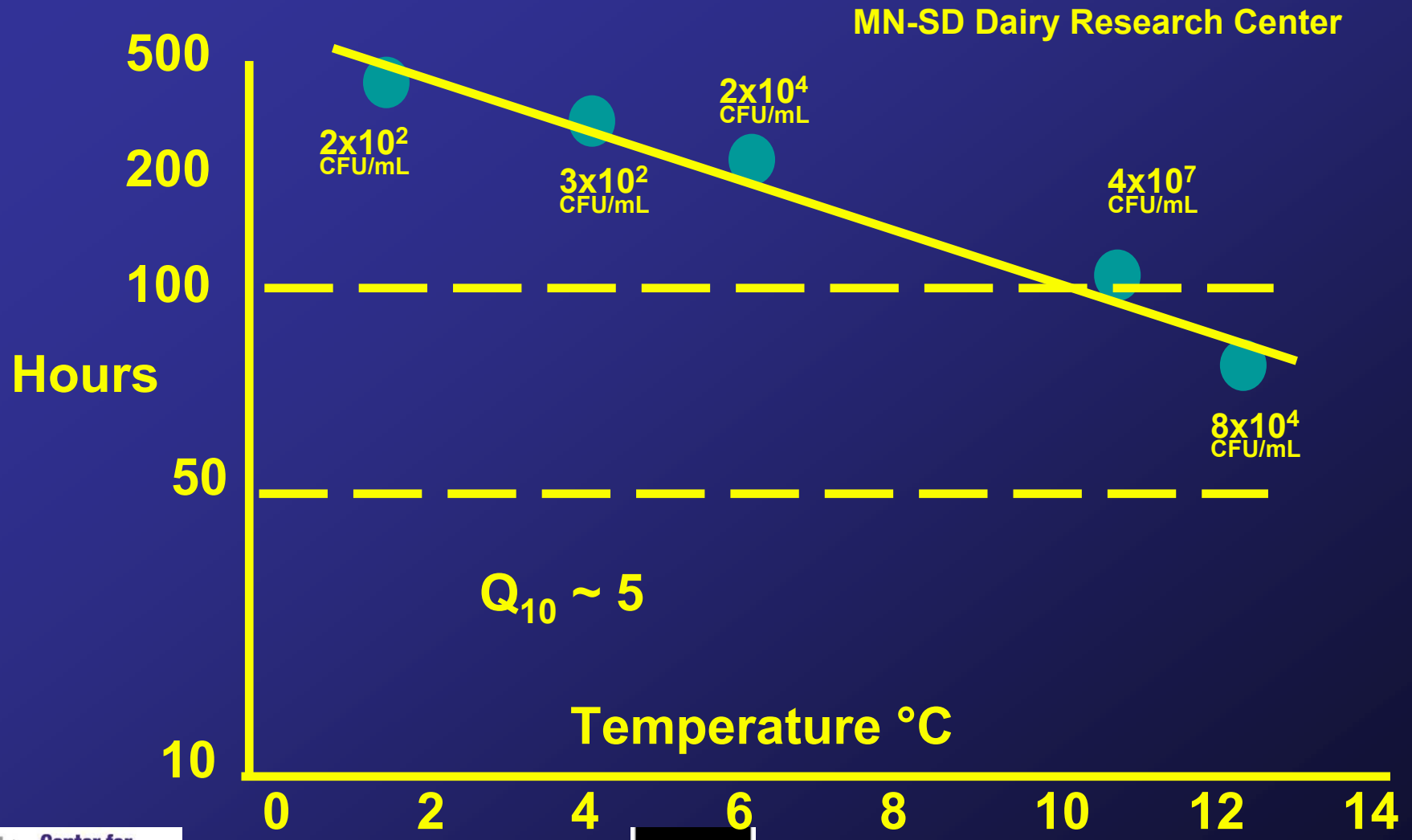
Sensory Shelf Life of Specialty Skim Milk



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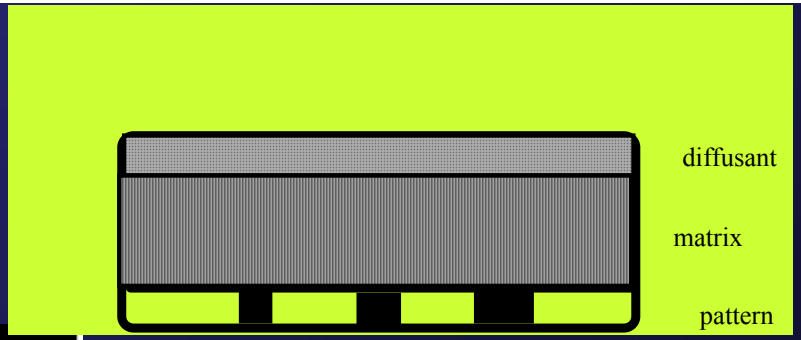
US Patent 5,667,303

- Time-Temperature Integrating Indicating Device Arens et al. 3M 9/97
- New concept of a diffusion tag with variable E_a based on WLF kinetics
- Range 15 Kcal to 30 Kcal/mole



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Lifelines acetylenic monomer tag polymerization catalyzed by Pt

Activation Energy ~ 19 - 30 Kcal/mole

QuickTime PICT

QuickTime PICT

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Vaccine Vial Monitor (VVM) Lifelines

- WHO mandated programs for health care and food safety.
  - Vaccine Vial Monitors mandated by World Health Organization and UNICEF
  - ISO 9001.2000 and HACCP
- Sold > 120 million "Heatmarker" labels for polio VVM (100% of WHO requirement)
- http://www.fsci.umn.edu/Ted_Labuza/PDF_files/papers/Vaccine_TTIuse.pdf

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VITSAB enzyme reaction tag
Activation Energy ~ 20- 35 Kcal/mole

Many uses and part of S-MAS

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Tell the Truth Tape

Newsweek 9/28/98 pg 14

2CCC

THE MILLENNIUM NOTEBOOK

Safer Food for a Tastier Millennium

ORANGE JUICE PASTEURIZED with a pulsed electric field. Guacamole and raw oysters subjected to pressure three times higher than in the deepest part of the ocean. Burgers zapped with gamma rays. These are some of the technologies proposed to help keep the next millennium's food safe by destroying such nasty bacteria as *E. Coli* 0157:H7 and *Vibrio vulnificus*. This high-tech barrage alarms some gourmets, who worry that taste will be obliterated along with the microbes. "Tasty is the word," says Sheila Lukins, author of the "USA Cookbook." "I think that's so disgusting."

Increasingly, food processors—who don't want their brand names linked to any of the 9,000 deaths each year related to food poisoning—are adopting hospital-like standards of cleanliness. One such outbreak can cost millions in penalties, lawsuits and lost business. In July, Odwalla Inc. agreed to pay a $1.5 million fine for selling apple juice that killed a 16-month-old girl and sickened 70 other people in 1996. In February, beef suppliers agreed to pay the parent company of Jack in the Box, a fast-food chain, $50.3 million in a settlement over tainted meat that killed four and sickened 000 in 1993.

Microbiologists and food scientists are proposing alternatives to much-debated irradiation techniques, which have raised environmental and worker-safety concerns. At a luncheon earlier this month, National Center for Food Safety and Technology director Charles Sizer proudly whipped up no-germ fare such as guacamole processed with 90,000 pounds per square inch of pressure—more than the force unleashed to firing a naval cannon. It allegedly tastes no different from regular guacamole but stays green longer. There are a few drawbacks: high-pressure processing kills only bacteria, not necessarily worker-spread viruses such as hepatitis. And it requires bulky equipment to contain all that pressure; you don't want to have to install a cannon in your kitchen. Sizer's feast also included orange juice pasteurized at a comparatively low 86 degrees with a pulsed electric field that kills bacteria and increases shelf life without changing the taste. Today orange juice is pasteurized at about 200 degrees, which is why it doesn't taste as sweet as when it's freshly squeezed.

Technologists and consumer advocates—spurred on by the president's creation of an interagency Council on Food Safety last month—are also working on a smorgasbord of other ways to quell germs. Meatpackers can steam-pasteurize carcasses to kill bacteria (but this works only on the surface), and poultry to prevent intestinal contents from contaminating the meat during processing and use healthy bacteria to crowd out pathogens in animals' intestines. Two weeks ago microbiologists at Cornell University reported that simply switching cattle from a diet of grain to one of hay or fresh grass for five days before slaughter dramatically reduced the incidence of harmful strains of E. coli. And a year ago, Crystal Farms started selling eggs pasteurized in their shell (at very low heat) to consumers in Minnesota, Wisconsin, Iowa and North Dakota. They are safe to eat raw or undercooked—in everything from eggnogs to sunny-side-up eggs. And expect more breakthroughs in "aseptic" packaging, the same technology that's brought Americans long-lasting juice boxes for kids.

Hook, line and zapper: Soon you can dig in with fresh confidence

Manufacturers will still remain dependent on good refrigeration and safe handling by truckers and supermarket employees. Ted Labuza, professor of food science and engineering at the University of Minnesota, has designed a special "tell the truth" tape that records a food's "time-temperature history" and turns a darker gray when the food is spoiled. Maybe soon we'll be able to shed our worries when we indulge in foods like steak tartare, rare hamburgers, oysters, eggnog and, yes, raw cookie dough. Here's to a tasty future.

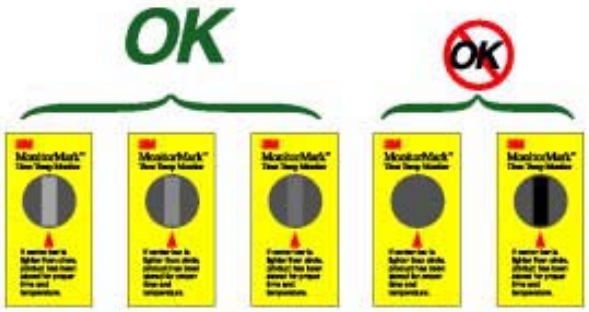
RAMIN SKIBOLA

The Price of Health

Overall spending on health care in the U.S. will double in the next decade despite slower growth in the public sector.

98 NEWSWEEK SEPTEMBER 28, 1998

"Manufacturers will still remain dependant on good refrigeration and safe handling by truckers and supermarket employees. Ted Labuza, professor of food science and engineering at the U of M, has designed a special "tell the truth" tape that records a food's "time-temperature history" and turns a darker gray when the food is spoiled."



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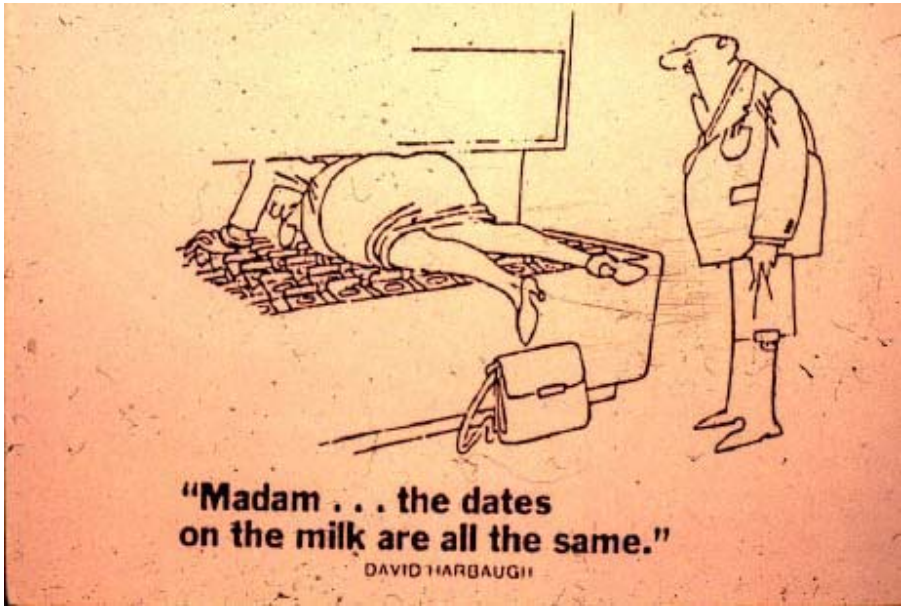
TTI Problems

- need marker for shelf life
- Need to collect food E_a data
- Must match tag kinetics to activation energy and run-out time of food - time consuming
- Food (or tag) must not have history effect

- ease of reading end point
- sorting



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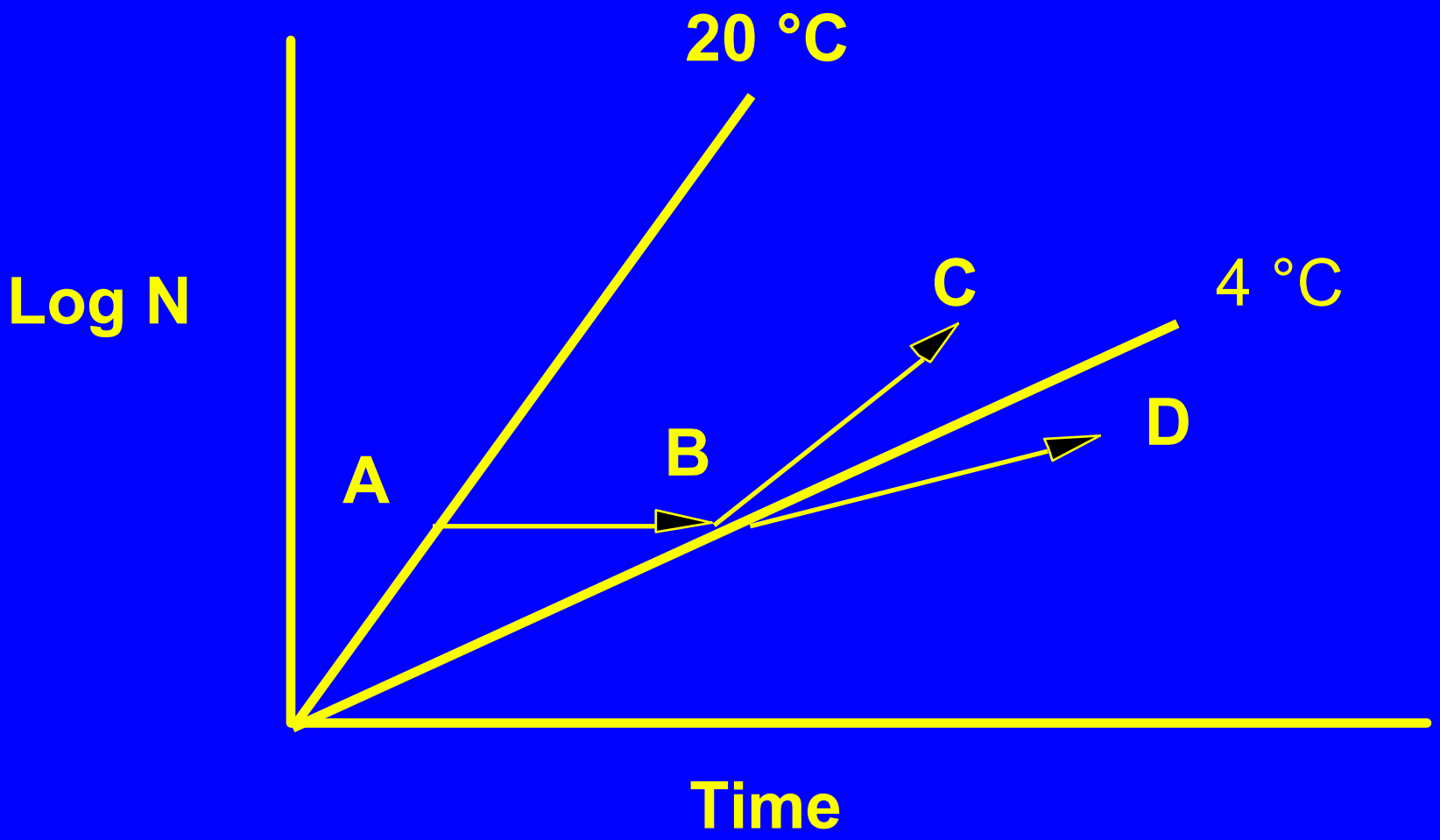

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Commercial Application Problems

- Don't want to know about problem
- Liability if tied to safety
- Marketer's resistance to cost
- BUT!!!! Tracing with time-temperature logging is insurance policy and gets "who did it"

- So paradigm shift to electronics

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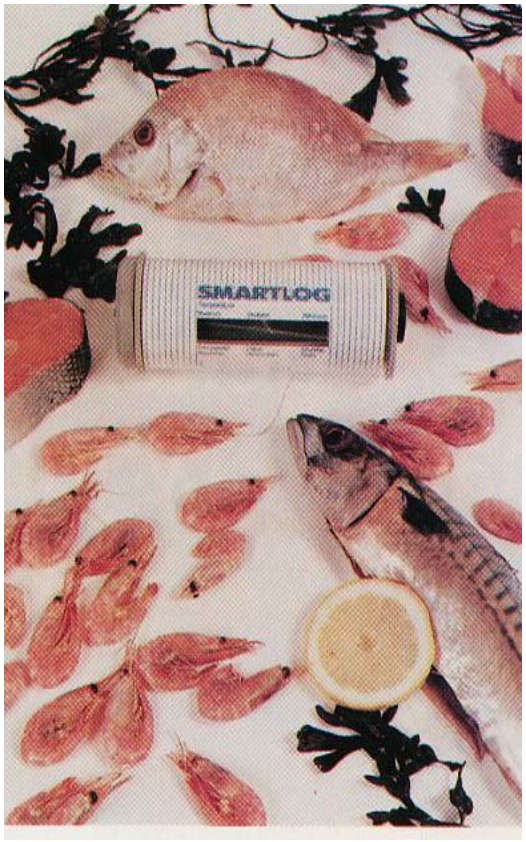
Reymomsis Fish Shelf Life Data Logger and Integrator 1970



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For fresh

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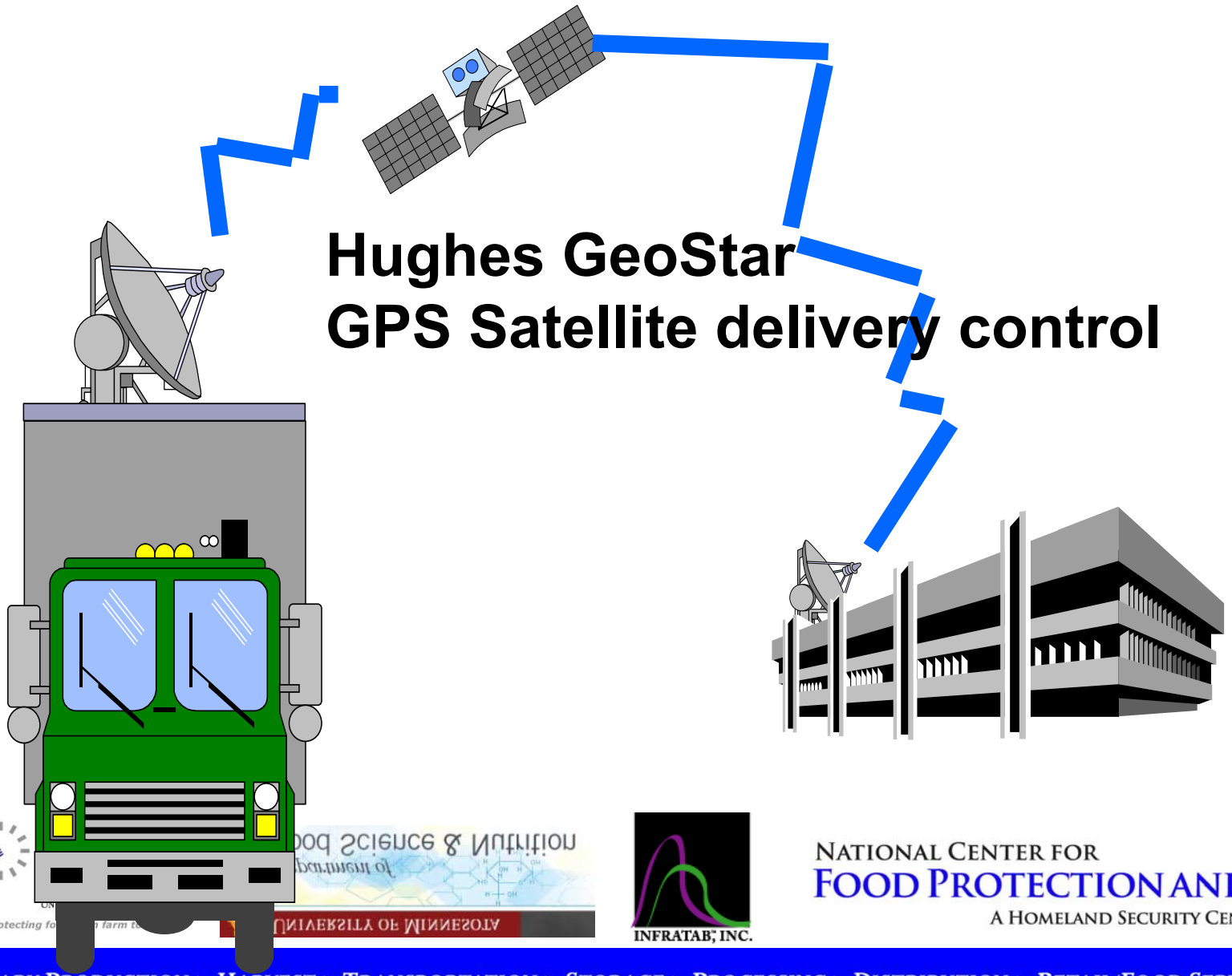
Logistics management and Profitability ECR



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1990's generation electronic sensors data loggers for t/T

- Comprised of
- thermocouple or thermistor sensor
- clock oscillator
- memory chip
- microprocessor
- RS232 port for output to computer

Data loggers

- Reusable
- $10-$50 cost
- Designed for distribution system
- Re-useable

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Determination of Effect of Time/temperature Distribution on Shelf Life or quality loss

Input the product name or code here: *Salmon Shelf Life* Reference:

Data limited to three temperatures

Input the initial and final quality values (cannot be zero for 1st order) for most foods use As=2

Define: Initial Quality Ao = 100 End Value As = 2

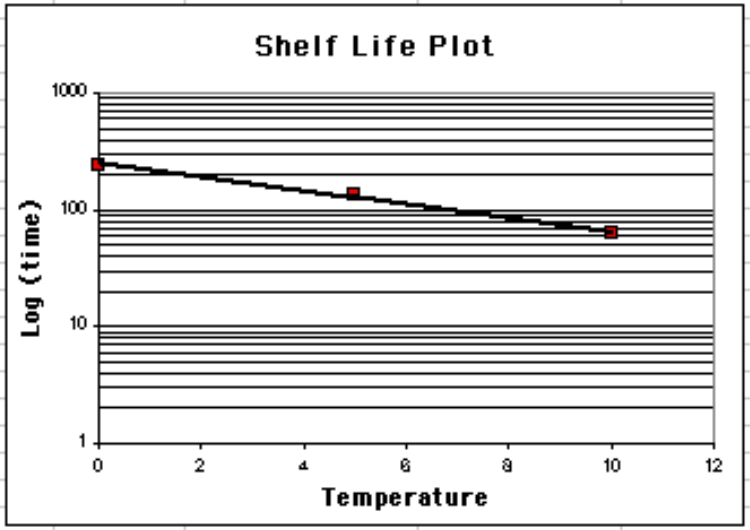
Note a key here is what you choose as an endpoint

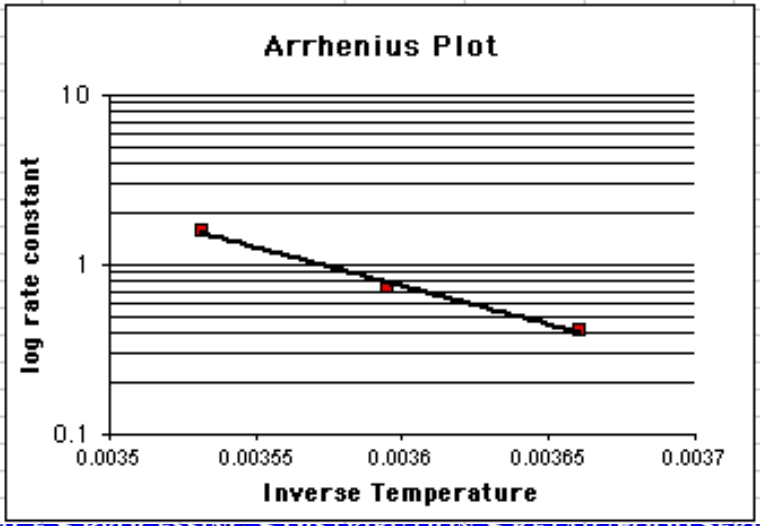
This should be discussed with an Infratab scientist

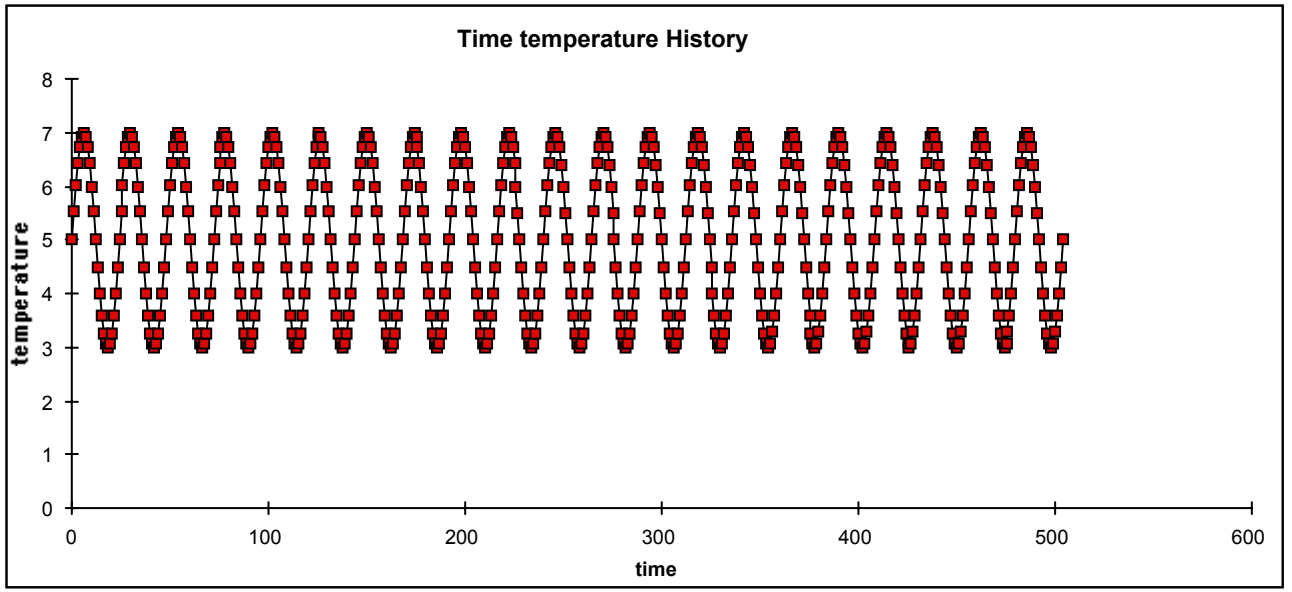
Input the temperature and shelf life time

Input		Kinetic parameters			
Temp °C	Shelf life time in *hours*	Shelf Life Constants		*Shelf life equation ts=to(exp(-bT))*	
0	242.4	to	248.18	*shelf life at T= 0°C*	*r2* = 0.98
5	132	b	0.14	*slope of shelf life plot*	
10	62.4	Q10	3.88	*rate increase for a 10°C increase in temperature*	
		zero order Ea	20.82	*kcal/mole*	
		ko	1.82E+16	*zero order preexponent of k = ko exp(-Ea/RT)*	
		first order Ea	20.82	*Kcal/mole*	
		ko	7.28E+14	*first order preexponent of k = ko exp(-Ea/RT)*	
		r2	1.00		

	zero order		first order	
Temp °C	inverse temp	rate constant	ln k	k first	lnk first
0	0.003660992	0.404290429	-0.905621776	0.0161387	-4.12653462
5	0.003595182	0.742424242	-0.297834444	0.0296365	-3.51874729
10	0.003531697	1.570512821	0.451402203	0.0626927	-2.76951064

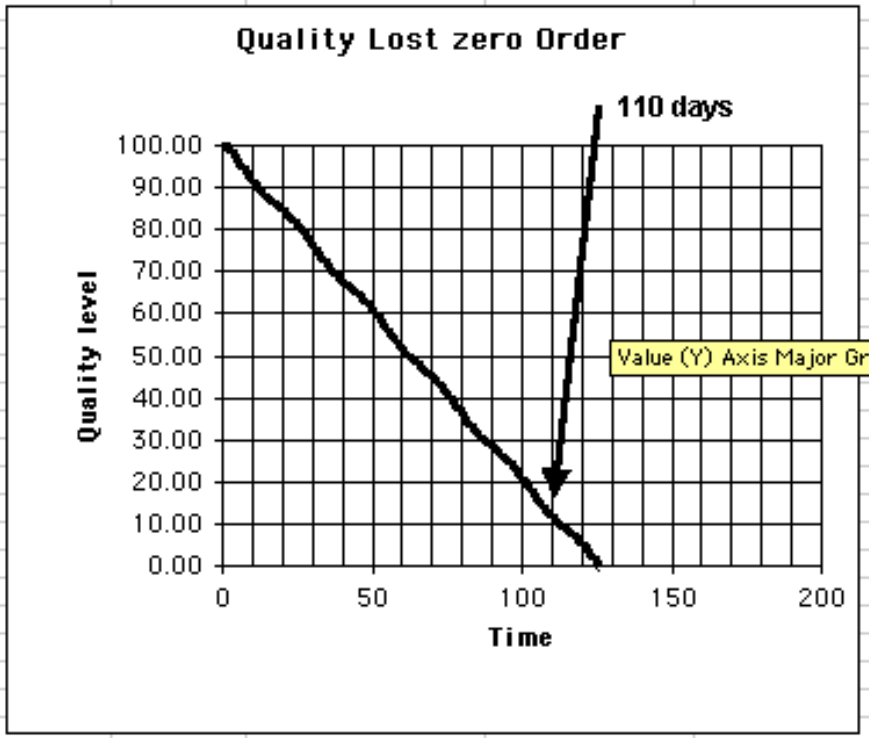




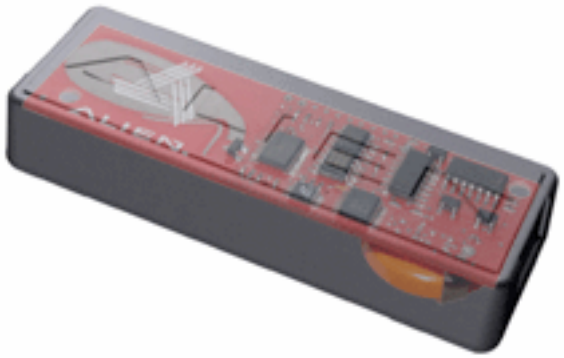


Download			zero-order			Zero Order	first-order			1st Order
Time	Temp.	Delta time (Δt)	kT	kTΔt	Sum(kTΔT)	A	kT	kTΔt	Sum(kTΔt)	A
0	5		7.85E-01			100.00	1.75E-02			100.00
1	5.517655	1.00	8.42E-01	0.84	0.84	99.16	1.77E-02	0.017673	0.01767252	98.25
2	6.000031	1.00	8.98E-01	0.90	1.74	98.26	1.78E-02	0.017813	0.03548519	96.51
3	6.414252	1.00	9.50E-01	0.95	2.69	97.31	1.79E-02	0.017941	0.05342617	94.80
4	6.732087	1.00	9.91E-01	0.99	3.68	96.32	1.80E-02	0.018045	0.07147095	93.10
5	6.931875	1.00	1.02E+00	1.02	4.70	95.30	1.81E-02	0.018112	0.08958343	91.43
6	7	1.00	1.03E+00	1.03	5.72	94.28	1.81E-02	0.018136	0.10771946	89.79
7	6.931819	1.00	1.02E+00	1.02	6.74	93.26	1.81E-02	0.018112	0.12583192	88.18
8	6.731979	1.00	9.91E-01	0.99	7.73	92.27	1.80E-02	0.018045	0.14387666	86.60
9	6.4141	1.00	9.49E-01	0.95	8.68	91.32	1.79E-02	0.017941	0.1618176	85.06
10	5.999845	1.00	8.98E-01	0.90	9.58	90.42	1.78E-02	0.017813	0.17963021	83.56
11	5.517448	1.00	8.42E-01	0.84	10.42	89.58	1.77E-02	0.017672	0.19730267	82.09
12	4.999785	1.00	7.85E-01	0.78	11.21	88.79	1.75E-02	0.017532	0.21483511	80.67
13	4.482137	1.00	7.31E-01	0.73	11.94	88.06	1.74E-02	0.017402	0.23223749	79.28
14	3.999783	1.00	6.85E-01	0.68	12.62	87.38	1.73E-02	0.017289	0.24952699	77.92
15	3.585597	1.00	6.47E-01	0.65	13.27	86.73	1.72E-02	0.017199	0.26672552	76.59
16	3.267806	1.00	6.20E-01	0.62	13.89	86.11	1.71E-02	0.017132	0.2838578	75.29
17	3.06807	1.00	6.03E-01	0.60	14.49	85.51	1.71E-02	0.017092	0.30094992	74.01
18	3	1.00	5.97E-01	0.60	15.09	84.91	1.71E-02	0.017079	0.31802862	72.76
19	3.068236	1.00	6.03E-01	0.60	15.69	84.31	1.71E-02	0.017092	0.33512078	71.53
20	3.268128	1.00	6.20E-01	0.62	16.31	83.69	1.71E-02	0.017132	0.35225312	70.31
21	3.586052	1.00	6.47E-01	0.65	16.96	83.04	1.72E-02	0.017199	0.36945176	69.11
22	4.000341	1.00	6.85E-01	0.68	17.64	82.36	1.73E-02	0.01729	0.38674138	67.93
23	4.482759	1.00	7.31E-01	0.73	18.38	81.62	1.74E-02	0.017403	0.40414391	66.75

	A	B	C	D	E	F	G	H	I	J	K
601	497	3.065866	1.00	6.03E-01	0.60	397.68	-297.68	1.71E-02	0.017092	8.73447178	0.02
602	498	3.00002	1.00	5.97E-01	0.60	398.28	-298.28	1.71E-02	0.017079	8.75155048	0.02
603	499	3.070478	1.00	6.03E-01	0.60	398.88	-298.88	1.71E-02	0.017093	8.76864308	0.02
604	500	3.272439	1.00	6.20E-01	0.62	399.50	-299.50	1.71E-02	0.017133	8.7857763	0.02
605	501	3.592139	1.00	6.48E-01	0.65	400.15	-300.15	1.72E-02	0.0172	8.80297624	0.02
606	502	4.007788	1.00	6.86E-01	0.69	400.84	-300.84	1.73E-02	0.017291	8.82026754	0.01
607	503	4.49106	1.00	7.32E-01	0.73	401.57	-301.57	1.74E-02	0.017405	8.83767208	0.01
608	504	5.009017	1.00	7.86E-01	0.79	402.35	-302.35	1.75E-02	0.017535	8.85520693	0.01
609											
610											
611	time	temp		zero-order			Zero Order	first-order			First order
612			Delta time (Δt)	kT	kTΔt	Sum(kTΔT)	Quality Left	kT	kTΔt	Sum(kTΔt)	Quality Left
613											



Alien Technology



- 915 MHz RFID tag read @ 15 meters
- User defined time intervals - 1000 values
- No integration but data logging of t/T
- Reusable with 5 year life
- http://www.alientechnology.com/
- Possible DOD use

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DAX

DAX
Cold Chain Management

Pilot Program
Produce Phase

Test Results

Presented
By

3PL Solutions

4550 W. Oakey Blvd, Suite 111
Las Vegas, NV 89102

In Cooperation With:

SYSCO

SYSCO Corporation
Supply Chain Services
Houston, TX

And

ALIEN.

Alien Technology
Morgan Hill, CA

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iButton

- Thermistor (-40 °C to +80°C) in Δ 0.5 C
- Clock/calendar (seconds up to years) @ ± 1 min/month
- Thermal history logger ~ 1 million points
- Extra memory for manifest
- http://www.ibutton.com/ibuttons/index.html
- Cost $2 to $53

Freshloc

http://www.freshloc.com/

t/T and t/%RH logging

How FreshLoc Works

The FreshLoc system is based upon tiny wireless sensors (shown here) that transmit continuously. It automatically and continually collects data such as temperature, humidity and other measures via a unique secure Internet connection.

In a given facility, FreshLoc sensors are arrayed and transmit wirelessly (for up to hundreds of feet) to a small reader / receiver which is connected to a gateway device allowing Internet connection.

With Internet connection, data is available for alerting and reporting via pager, fax, phone or email.

What Is Freshloc?

Dec. 13, 2002 - 7-Eleven Installs FreshLoc Technology in Combined Distribution Center for 692 Southern California Stores To ensure the freshness and quality of its fresh food and sandwich offerings, 7-Eleven, Inc. (NYSE:SE) is installing Cold Chain Control™ technology, a wireless, automatic monitoring system from FreshLoc Technologies (www.freshloc.com), in the Combined Distribution Center located in Fullerton, Calif. 7-Eleven aims to increase fresh food sales nationwide over the next five years. Cold Chain Control technology from FreshLoc helps to manage safe temperatures from a single distribution facility that serves Los Angeles/San Diego-area 7-Eleven stores.

Detecting all breaks in the cold chain

The CliniSense LifeTrack™

Product monitoring over the entire pharmaceutical lifetime

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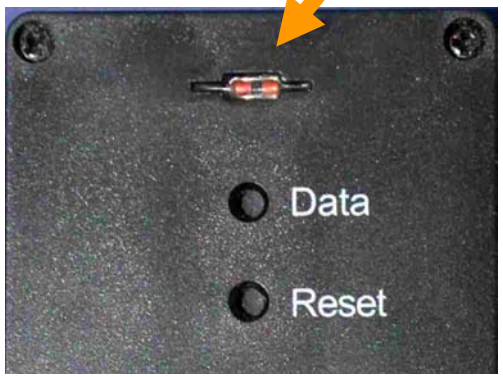
Clinisense LifeTrack unit

+/- good
bad
display

Lifetime
bar

Battery
door

Thermistor



Infrared
LED

Programming
& expansion
Port

Battery
(3 yr life)

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US & foreign patents pending

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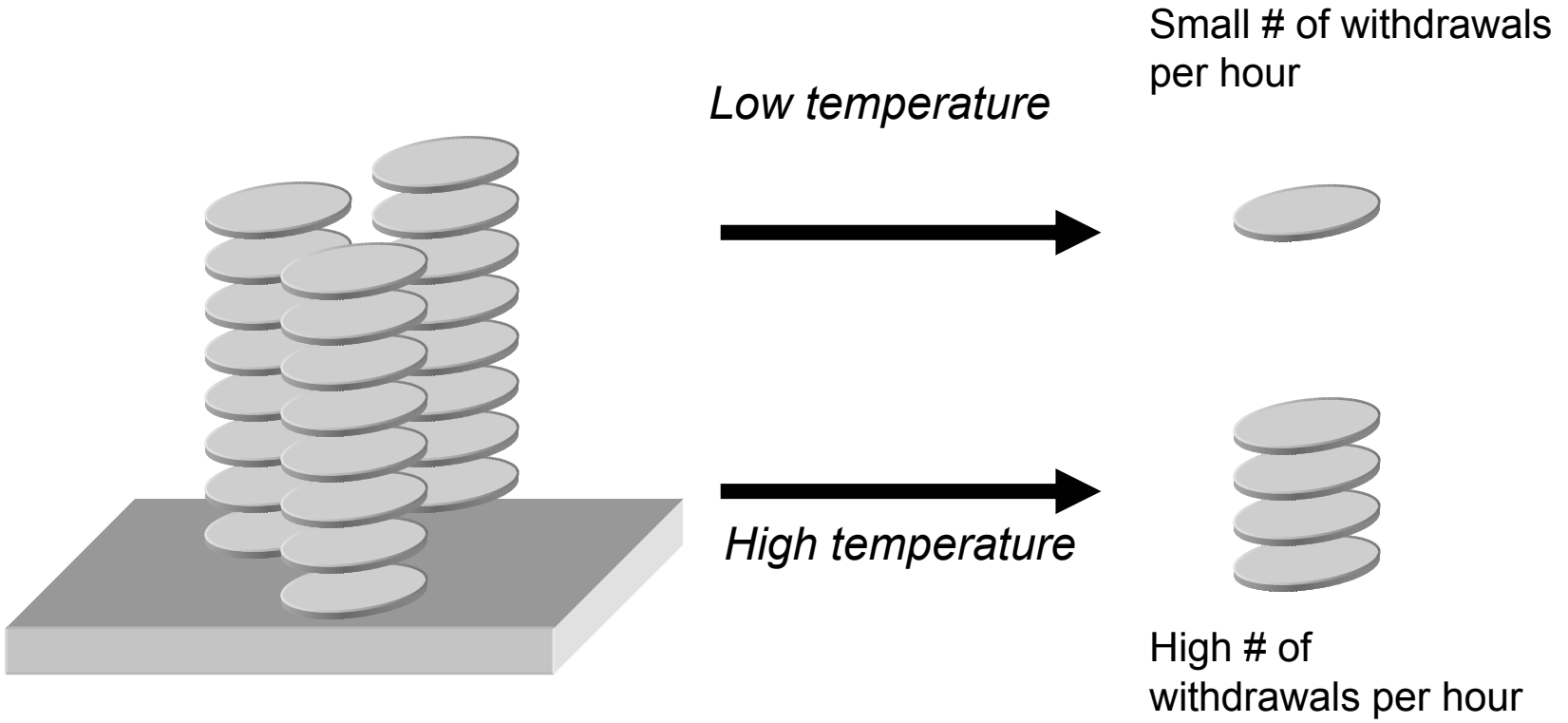
The stability bank algorithm

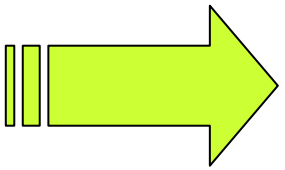


Stability bank "B"

3M Chilean Electronic logger

Informatics UPC paradigm shift to ePC

- **Traceability**



2002 Biosecurity Act empowers FDA to require traceability (one step back & forth)

2006 FDA and USDA issue proposal to tie use by date to food safety - need for t-T data

EU directive 178/2002 Article 18 traceability 2005

Country of Origin (wine, cattle (BSE), fish, cheese, fruits & veges etc)

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What do we want to do ?

- Get the location of a lot of food in the cold distribution chain in case of an event (recall or bioterror event) ?
- Where did ingredients come from?
- What about the ingredients in ingredients?
- What line, batch #, date, time was it made on?
- What is the shelf life left of the product?
- Is the food safe when we eat it, either by sensing agents or by modeling?

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EU Requirement
178/2002 Article 18 Traceability 1/1/05

According to comments received, firms exporting from the European Union (EU) are already subject to similar recordkeeping requirements under EU regulation 178/2002. Article 18: *Traceability* of the EU regulation states:

* * *

(1) The traceability of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.

(2) Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed. To this end, such operators shall have in place systems and procedures, which allow for this information to be made available to the competent authorities on demand.

(3) Food and feed business operators shall have in place systems and procedures to identify the other businesses to which their products have been supplied. This information shall be made available to the competent authorities on demand * * *. (Ref. 14).

All stages- production, processing & distribution

Food, animals, ingredients and feed

Info available on demand

Forward and backward

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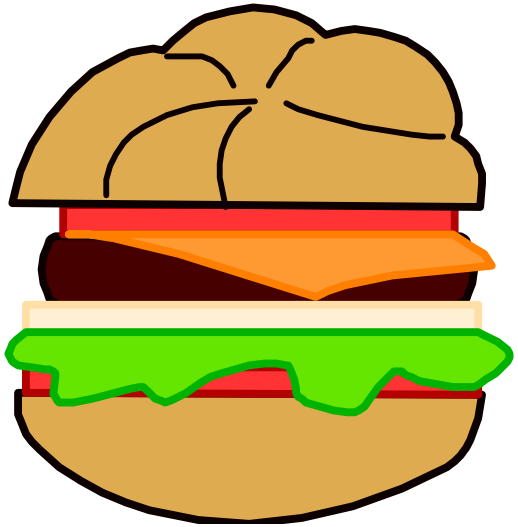
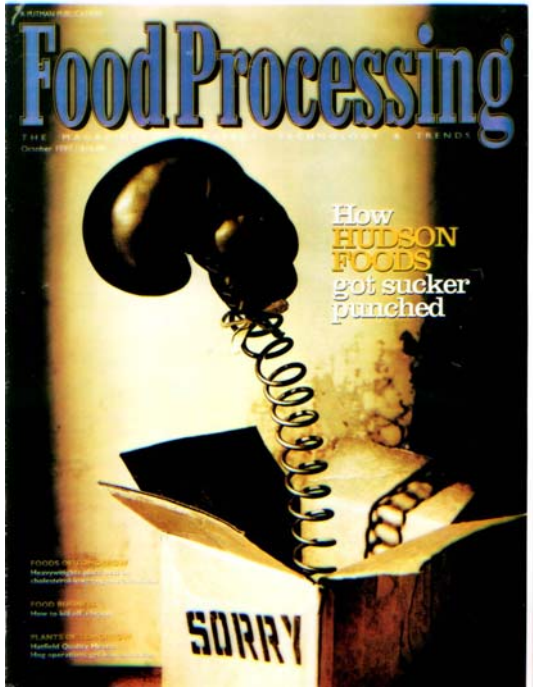
Meat traceability and recalls

- August 2002 19.8 MM lb hamburger recall
  - 30 ill with E coli O157:H7
  - 1 death
  - Only 8000 lbs back
  - Had a 3.5% rework policy





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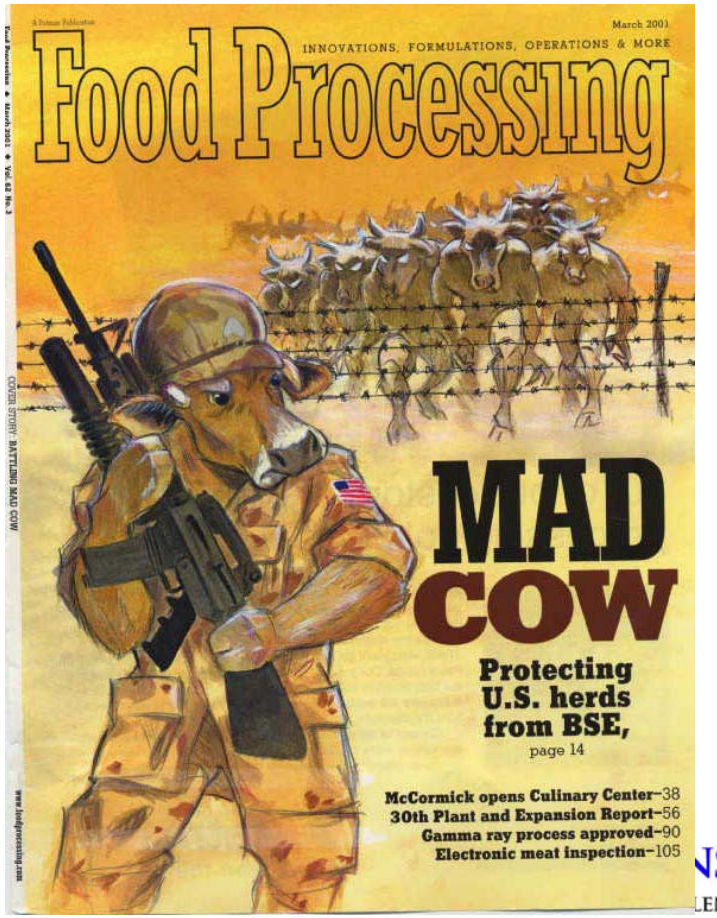
One cow with BSE -->damage

- In 2002 Canadian exports of beef were $4 billion
- On first day (5/20/03) McDonalds lost $1.2 Billion in stock market
- Canadian farm losses were $11 MM/day
- Feedlot losses (1st month $400 MM)
- in July $3.1 billion outstanding loans
- August 2003 total loss $42 billion
- Today $11 MM per week
- GNP reduction ~1%



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Journal of Food Protection, Vol. 68, No. 8, 2005, Pages 1761–1775
Supplement

Considerations for Establishing Safety-Based Consume-By Date Labels for Refrigerated Ready-to-Eat Foods

ADOPTED 27 AUGUST 2004, WASHINGTON, D.C.
NATIONAL ADVISORY COMMITTEE ON MICROBIOLOGICAL CRITERIA FOR FOODS

NACMCF Executive Secretariat,* U.S. Department of Agriculture, Food Safety and Inspection Service, Office of Public Health Science, Room 333 Aerospace Center, 1400 Independence Avenue S.W., Washington, D.C. 20250-3700, USA

MS 05-701: Received 7 February 2005/Accepted 1 March 2005

Wine origin by unique DNA

Anti-counterfeit DNA labels

Applied DNA Sciences Inc.

Stony Brook NY adnas.com

Electronic scanners detect the DNA in the ink, and the ink itself can be tested for the presence of the vine's DNA.

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Electronic "Smart Labels" for TTI

- Driven by
  - Current TTI- No data storage to find weak link (insurance)
  - Electronics got smaller so can be on consumer package
  - Move towards electronic tags with RFID to "read at a distance" and to replace bar codes with traceability
  - Can build in run out time and activation energy on computer chip so kinetics match is easy to do
  - Can put in multiple modes of deterioration (eg TTD, lag, log growth phase)
  - Can create sharp end point
  - Electronics does not have history effect
  - Decision making based on LSFO vs old FIFO
  - Combine with traceability

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KSW Microtec AG

DIN ISO 15693-3

3 V 13.56 MHz

Memory 4 blocks 256 Bytes R/W

time sampling 10 sec to 16 hr

-15 °C to 50 °C

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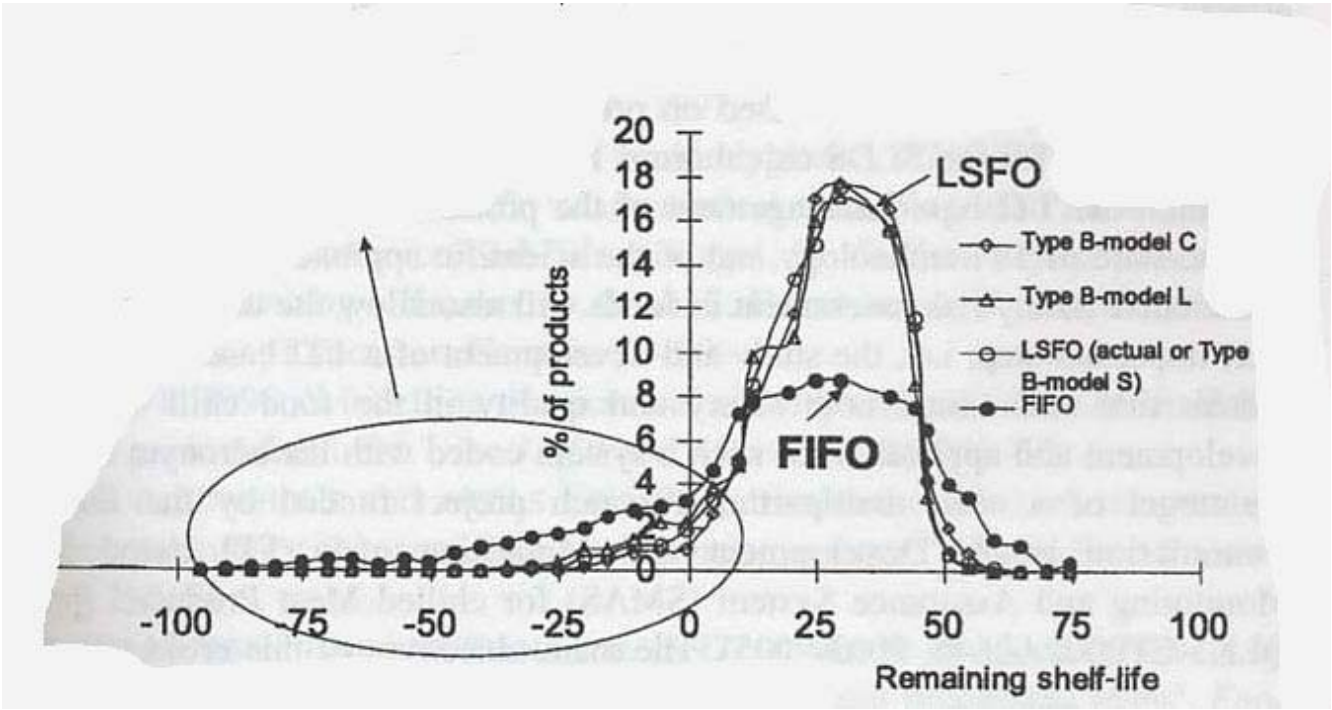
Eliminate shrink



Ship based on least shelf life left (LSFO) JFS 68(1):201-9

J Food Protection 64(7): 1051-57 http://smas.chemeng.ntua.gr

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SUPPLY CHAIN BENEFITS

www.infratab.com FDA traceability requirements plus TTI

Shipping
• *Perishable Shipping Services*

Shelf Life-Based Logistics based on LSFO

Induction
• *Processing*
• *Identification*
• *Sortingfor trp*

Product Received is OK—
Shelf Life Left:
62 %

DCs
• *First In*
• *Least Shelf Life Out*

Release this FIRST..At this temperature the shipment must arrive at the retailer in 3 days

Re-order

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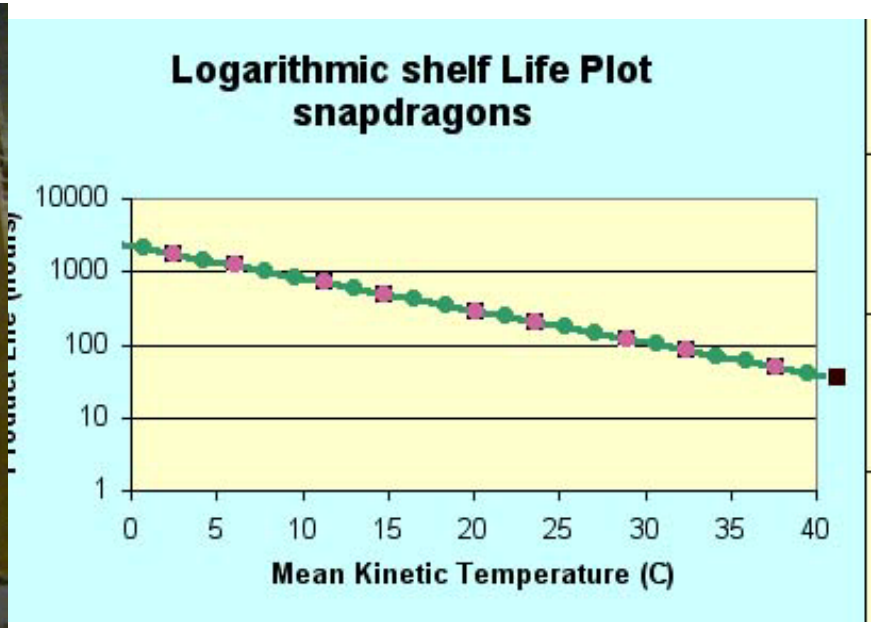
Flower study - logistics management and marketing



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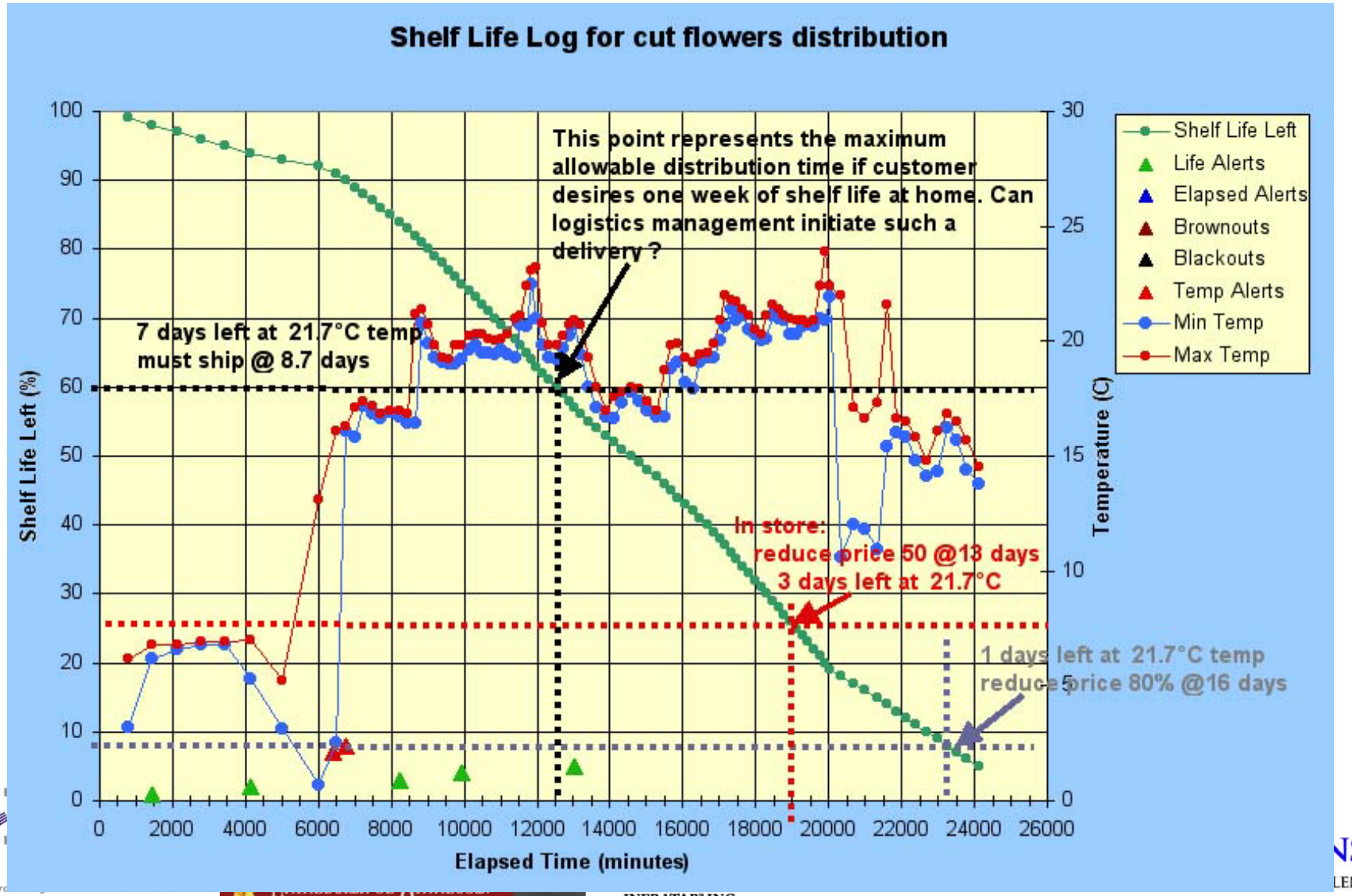
Flower distribution management



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Bioett

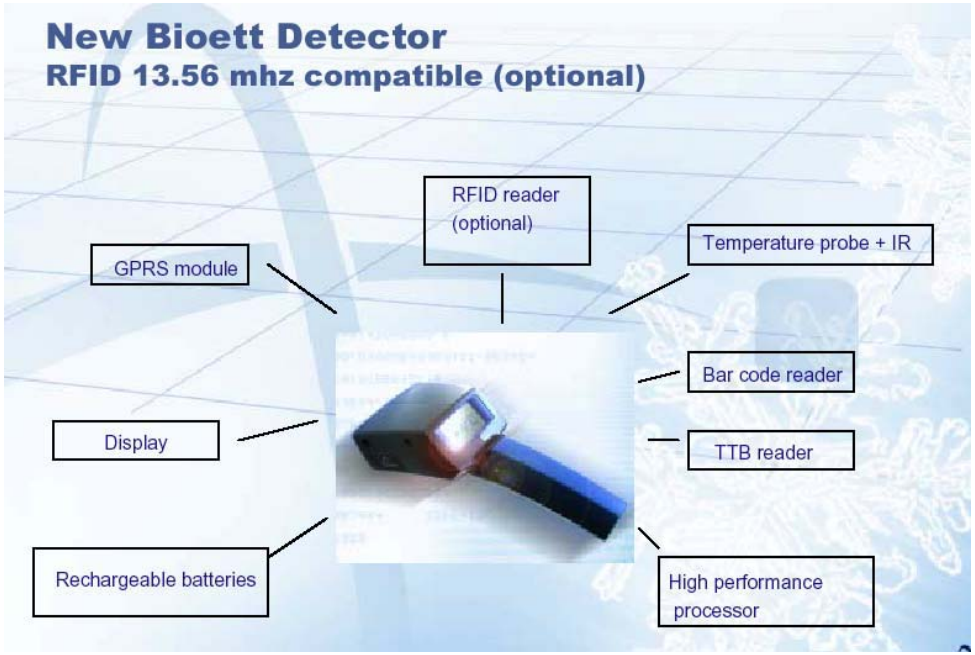
The Bioett System™

BIOSENSOR

TimeTemperatureBiosensor - TTB™

New Bioett Detector

RFID 13.56 mhz compatible (optional)



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Micro-electronic TTI tag vendors

- Technopuce (France)
  - Acti-Tag RFID TTI for t/T integration
  - Hemo-Tag TTI for blood (two technology awards)
  - http://www.technopuce.com/

Actitag™
The Active Intelligent Label

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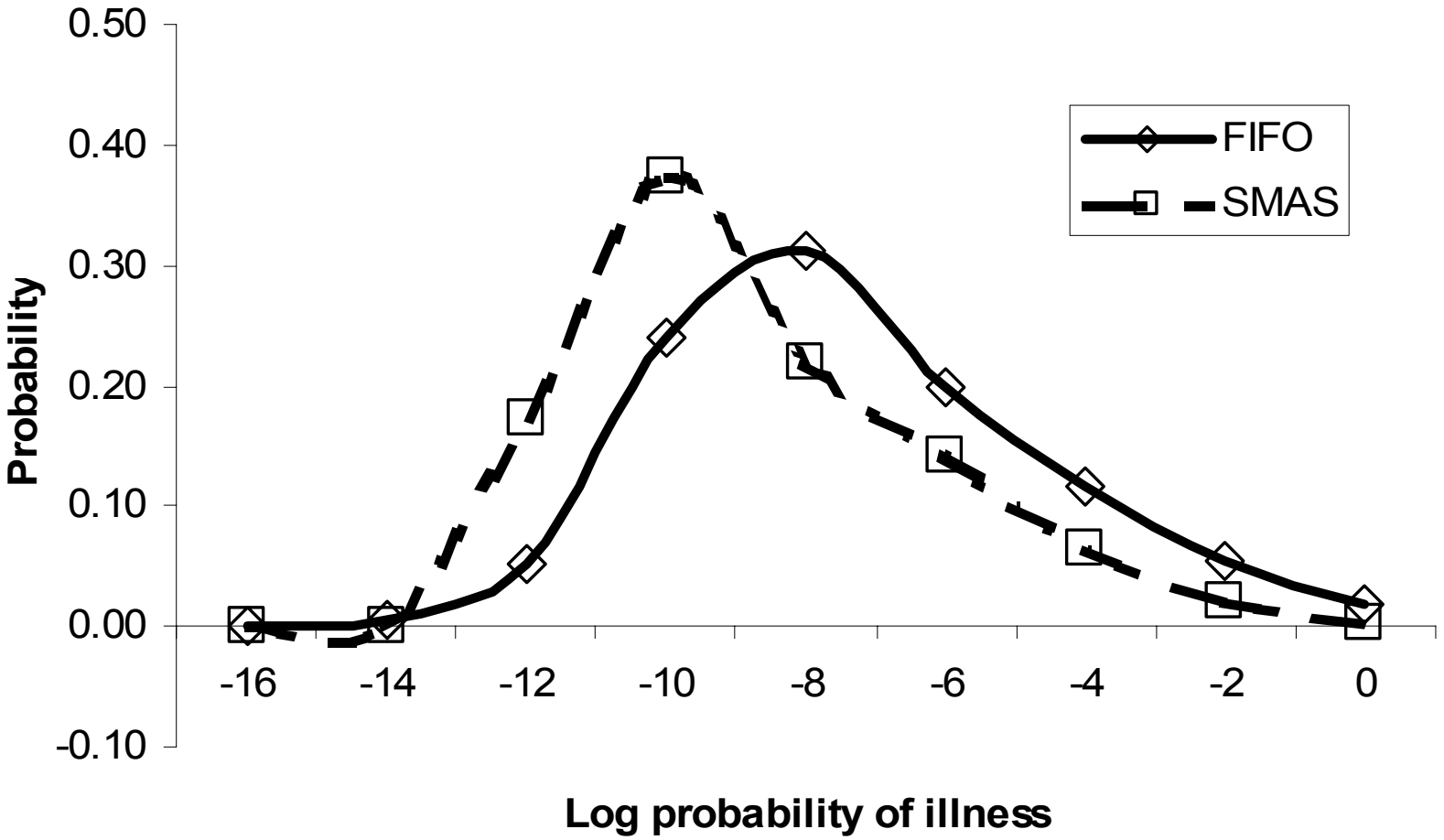
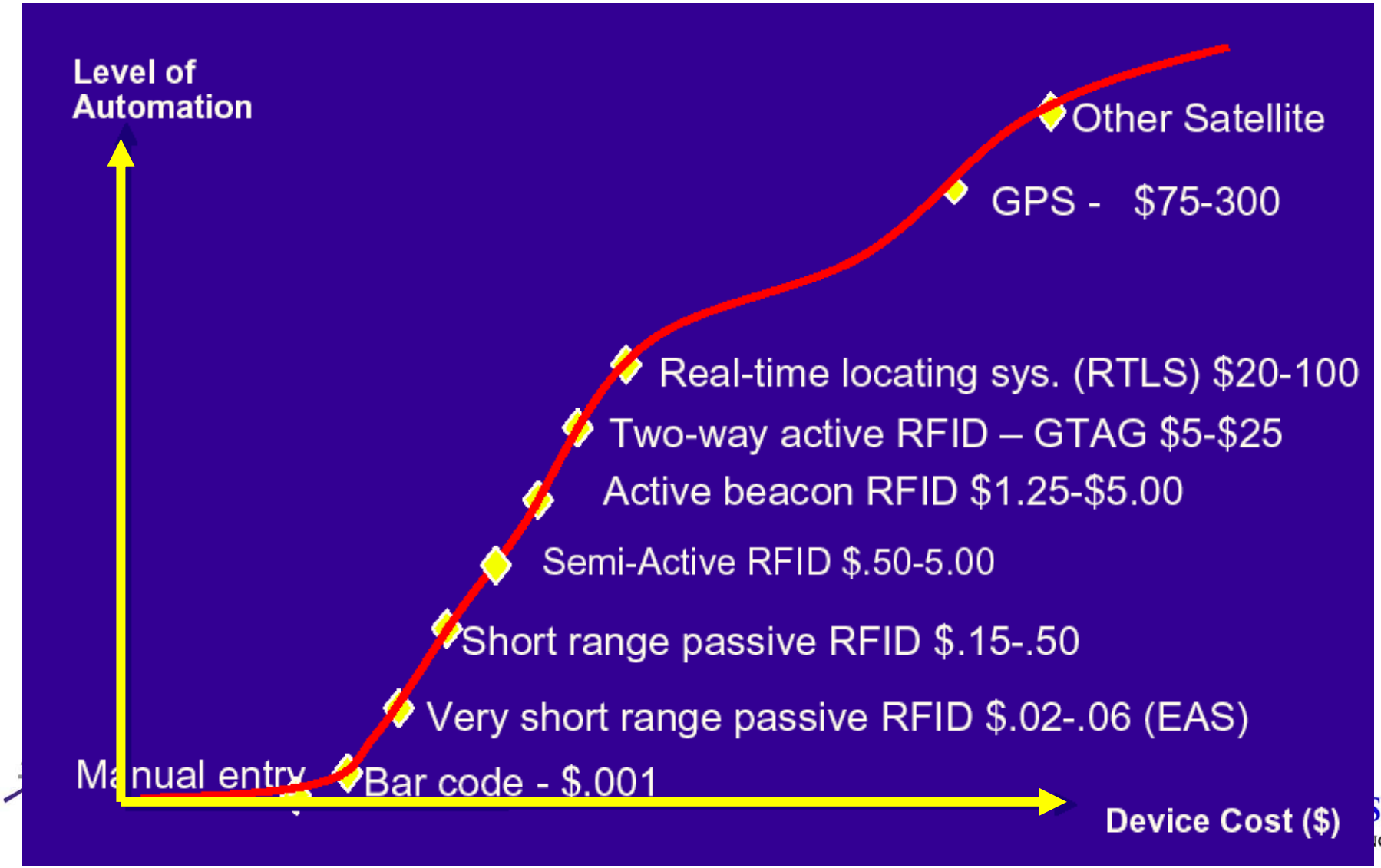
Reduces probability of food poisoning



Critical Factor - Cost



Critical Factors - technology

- Choice of frequency ISO standards 13.54 Mz
- Data standards ePC Global
- Water absorption of μ-wave reduces power to read at a distance - size and antenae design
- Reflectivity of metal (foil pouches, metal cans, foil liners)
- Standards for readers
- Software compatibility - middleware
- Data security
- Time-temp algorithms

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Use concerns

- Error rate on line
- Influence of environment on tag
- Recycling prohibitions if on primary package & single use
- Ease of returnability if multiple use
- Environmental disposal (EPA)
  - Heavy metals in battery and board/chips
  - organics

Traceability concerns

- 4th amendment rights of privacy
- Cost of implementing RFID vs paper files
- Pallets vs cases vs packages (TRU)
- Standards for data security during collection, management and sending
- KISS software
- Palm/reader compatibility

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Positives of RFID & TTI (or other sensing)

- Reduce shrink
- Capture problems on the run (who's the culprit)
- Improve safety (foods, drugs, diagnostics, vaccines, medical devices, blood, organs)
- Improve traceability for recalls
- Enhance functionality (munitions, epoxy, paints, fine chemicals, film)
- Logistics and traceability (cattle & BSE)
- You name it !!!

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Other applications

- Ensuring proper medication in hospitals
- Sentinel chickens for avian flu (H5N1) detection
- Tracing lost pets
- Taking pet's temperature
- Alcohol blood sensor in-plant for alcoholics
- Tracing sex offenders
- Tracking lost children (the Matrix)
- Country of origin

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